

GENETICALLY IMPROVED CONIFERS FOR THE LAKE STATES

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The Lake States provenance test of jack pine was started by Paul Rudolf of the USDA Forest Service in 1951. That marked the beginning of two decades of serious tree improvement research in the region. In this paper I shall recount some of the progress that has been made. But it is also necessary to consider the extent to which genetic improvements have been put to practical use. We cannot expect continued research support without providing evidence that better trees are being planted because of our efforts.

GREAT GAINS IN CHRISTMAS TREE SPECIES

The past two decades have seen the rise of a sizeable Christmas tree industry based upon plantation culture. Planted Scotch pine, white spruce, Douglas-fir and a few other species have all but replaced the wildlings of 20 years ago. I do not have figures for all States, but in Michigan there are about 10,000 Christmas tree growers and the annual harvest is more than 5 million trees; the good trees wholesale at prices of \$1.75 per tree and up. Tree improvement research has had a great impact on the Christmas tree industry. It is probable that between 75 and 95 percent of the nursery stock available in 1971 bears some imprint of tree breeders' activities.

Scotch pine is the most popular Christmas tree in this region. It is an extremely variable species geographically, with 4 to 1 differences in growth rate, variation from lemon-yellow to dark-green winter foliage, 2 to 1 differences in needle length, and corresponding variation in other traits. Prior to 1960, many growers planted varieties that turned yellow in the autumn; such varieties had to be sprayed with green paint at a

cost of \$0.25 per tree if they were to be sold. Also, varieties from Belgium, northern France, and the western part of West Germany were commonly planted. Those varieties have moderately acceptable color and grow so rapidly as to require that every branch be sheared every year. The introduction of dark-green, slower growing varieties from southern Europe has resulted in increased tree quality and lower production cost. The color improvement alone is worth from 0.5 to 1 million dollars per year to the growers. Also, evidence this past year indicates that southern varieties are much the most resistant to pine root-collar weevil.

White spruce is another high-volume Christmas tree. Native seed has been used most commonly. Trees grown from seed collected in eastern Ontario grow 10 to 15 percent faster, which means a reduction of 1 to 2 years in rotation length.

Douglas-fir, the high-volume Christmas tree of the Pacific Northwest, is also much in demand in the Lake States, commanding wholesale prices of \$4.75 per tree. This, like Scotch pine, is an extremely variable species geographically. Much of the stock planted prior to 1965 in Michigan was grown from seed collected in central Montana, the home of slowest growing of all races. Rotation ages of 15 to 20 years were commonly assumed to be necessary and there was little profit even at \$4.75 per tree. Now there are 10-year provenance-test data showing that Douglas-fir from Arizona-New Mexico and northern Idaho can be marketed in 5 to 8 years.

Genetics research has also resulted in improvements in four other species — balsam fir, Fraser fir, white fir and southwestern white pine. Trees of those species promise to be of premium quality and could be grown on 5- to 8-year rotations.

REASONS FOR PROGRESS IN CHRISTMAS TREES

It so happens that most species being used as Christmas trees are extremely variable geographically. Provenance tests of a simple kind could show the presence of dramatic differences in growth rate and various other traits. It also happens that many growers in the past inadvertently chose the worst possible seed sources. Thus, it has been possible to obtain very dramatic improvements with a minimum of research effort.

Two other obvious factors should be mentioned. Christmas trees are short-rotation species amenable to quick improvement and tree breeders have paid some attention to Christmas tree problems. However, I do not think that either of these factors should be over-emphasized. The region's tree breeders have probably spent three times as much effort on timber and pulpwood problems as on Christmas tree problems.

Very important is the willingness of the Christmas tree industry to accept new developments. Christmas tree growers associations — both State and national — have annual meetings at which they solicit information on the latest developments in many areas — marketing, weed control, pest control, and new varieties. Also, these associations publish journals. All these factors have contributed to the fact that improvements have been put to practical use. The improvements have been dramatic, and Christmas tree growers have been interested in them. And, there are ways by which the information is effectively channelled to the Christmas tree growers.

Even so, success has not been automatic. It has been necessary for the researcher himself to do extension and development work. The Douglas-fir provenance test was started in 1962. A press release in 1965 elicited inquiries about recommended seed sources. No seed dealers or nurserymen handled the sources we were recommending. In 1968 we contacted foresters in Arizona and New Mexico, asking whether there was a cone crop and whether there were collectors. The replies were turned over to seed dealers. More press releases and technical articles appeared in 1970 and elicited more letters from growers and nurserymen. By that time we could recommend several seed dealers and one nurseryman as sources of Arizona-New Mexico stock. Hopefully by 1973 adequate supplies of the varieties now being recommended will be available in nurseries. Efforts such as this are necessary to make tree breeding results of practical value.

IMPROVEMENTS IN CONIFERS FOR ORNAMENTAL PURPOSES

The ornamental use of trees is receiving increasing attention. In the southern, nonforested half of the Lake States, trees possess more economic value as parts of the environment than as producers of raw material for industry. Even in the forested parts of the region, forest policy is often dictated as much by the recreation industry as by wood-using industries, and the public may consider esthetic aspects more important than wood-producing aspects. Thus, the ornamental values of trees cannot be overlooked.

Most improvement in this area has come through the use of species from other parts of the world. Of the 10 conifers most commonly planted for ornamental purposes in the Lake States, six were introduced from Europe, western United States, and Asia. Many other species could be added to this list — Japanese larch, Serbian spruce, and metasequoia, to name three. Most of the region's tree breeders work at least a little with exotics and are acquainted with little-known species that would be useful esthetically.

With the possible exception of jack pine, all the important Christmas tree, pulpwood, and sawtimber species in the Lake States are also useful ornamentals. Virtually all the tree improvement research being conducted in this region therefore relates to ornamental use. Consider for example, the finding that one variety of white fir grows twice as fast as another. That finding is equally important no matter what the reason for planting. Or, consider an improvement in the growth rate of eastern white pine. Growth rate is important whether the white pine is planted in a park or in a forest.

Thus, research directed toward the improvement of Christmas and forest trees has developed as a byproduct a number of findings important in the use of trees for esthetic purposes. Many more such results can be expected. However, the formal tree improvement programs have had almost no impact on esthetic forestry.

Esthetic and commercial forestry are very different in spite of the fact that both may deal with the same types of problems in the same species of tree. The region's tree breeders were trained in commercial forestry and are relatively unacquainted with the problems of esthetics. This is one of the reasons why our work has had little impact on the planting of trees for ornament. We have overlooked the esthetic value of a new

variety and have not known the channels by which to communicate with landscapers.

The introduction of a new ornamental into the trade is not an easy task. Norway spruce was introduced into the United States in the 1600's but only in 1876 did it become commonly distributed in the State of Pennsylvania. Japanese larch was introduced into the United States in 1861 and has become common in New York State during the past 30 years, but is not present in Michigan outside a series of 12-year-old experimental plantations. In Michigan it has obvious merit as an ornamental (also as a timber tree), but more than 110 years might have elapsed without its being used.

I wonder whether we must wait 110 years to introduce a new hybrid pine into the towns and roadsides of southern Michigan. This is a hybrid between Austrian and Japanese red pine. It can be mass produced cheaply, may be resistant to salt spray, and grows faster than any other hard pine in the State. It should be field planted as a 2-0 seedling, and that feature is a disadvantage. Nurserymen servicing the ornamental trade are accustomed to selling larger trees at a high per-tree price. To push this hybrid, we must show nurserymen and landscapers how to make money from 2-0 trees as well as show the merits of the tree.

Any newly developed tree must be marketed through commercial nurserymen. It is they who interpret the public's needs and satisfy those needs. They are private businessmen with profits to consider. For that reason they tend to emphasize clonal lines that can be patented and thus sold exclusively by a few people. Also, they emphasize those varieties which are in demand. They reflect the needs of the suburban homeowner rather accurately, but not the needs of the highway landscaper, the inner-city dweller or the manager of a large rural park.

In recent years large chain stores have become major outlets for nursery stock. Inevitably there has been a tendency to stock only one clone or variety of a single type of tree, a variety believed to be equally successful in Maine and Oregon. This practice is a hindrance to the introduction of a new variety believed to have merit in specific situations.

Formal tree improvement programs in the region have produced many results of value to esthetic forestry, and results of a type not to be expected from amateur breeders. The channels by which those results can be put into practice have not been developed. Real efforts should be made to develop these channels.

THE PRESENT STATUS OF IMPROVED TIMBER-TREE VARIETIES

Improvement of trees for timber production has been the major thrust of the region's tree breeders. Accomplishments, while not as spectacular as for the Christmas tree industry, have been considerable. In white spruce, increases in rate of height growth of 10 to 15 percent have been obtained by using seed collected from eastern Ontario in place of native seed. The increases would be much greater if translated into terms of volume growth. The growth differential was approximately the same whether the test was conducted in North Dakota, Wisconsin, or southern Michigan.

Norway spruce grows considerably faster than white spruce at many places in the southern and central parts of the Lake States. Also, it grows well in Michigan's Upper Peninsula and some other northern areas. On many sites, spruce rotations could be reduced 25 to 50 percent if this species were substituted for white spruce. Norway spruce is subject to attack by white-pine weevil and suffers from old age when it reaches a diameter of 18 inches. Even with those difficulties, Norway spruce grows straight and fast and to greater size than do our native species.

Eastern white pine from the southern Appalachians planted 12 years ago in southern Michigan is now 25 feet tall, surpassing native trees by 10 to 15 percent. Eastern white pine trees from southern Ontario are nearly as tall as those from Tennessee, although not as large in diameter. In tests conducted in Michigan's Upper Peninsula, white pines grown from seed collected in the Lower Peninsula grew 8 percent taller than Upper Peninsula trees. In experiments conducted in northern Wisconsin and northern Minnesota, trees from central Wisconsin grew most rapidly.

It is apparent that no one race of eastern white pine is best for all portions of the Lake States. But it is also apparent that there is a better type of white pine for almost every acre in the region. Increases of 10, 20 or even 30 percent in rate of volume growth can be expected by a judicious choice of seed sources adapted to particular sites.

Comparable gains have not been obtained in jack pine, where the fastest growing trees are from central Wisconsin and central Michigan. Jack pine growers in those areas should use local seed. There is evidence that moving central Wisconsin-central Michigan seed

northward into northern Wisconsin and parts of northern Michigan (but not into northern Minnesota) can result in a 5 to 10 percent gain in growth rate without encountering winter damage.

Plus-tree selection followed by grafting is the tree breeding method most commonly used in northern Europe and southeastern United States. Its possible usefulness in the Lake States has been tested by means of progeny tests. These are now well underway in five coniferous and one hardwood species. Except in white spruce, the results are negative — plus trees as selected in the fields have not produced superior offspring.

However, another breeding method known as family selection has been tried with some success. The goal of this method, as of plus-tree selection, is to make use of the genetic variability believed to be present in any natural forest for the production of a new variety superior to the wildlings now on the land. A red pine progeny test-seed orchard developed along these lines indicates a 2 to 3 percent gain in rate of height growth, with limited quantities of seed to be available in 1975. Although nursery measurements of a similar jack pine project indicated gains, measurements made 4 years after field planting leave the issue in doubt.

It is still too early to talk of the amount of improvement in tamarack, northern white-cedar, and balsam fir. There are sizable projects underway with these species but the experiments are young yet.

Japanese larch, unlike its relative the tamarack, is a moist upland species. It is a remarkably fast-growing species. Trees planted 12 years ago in northern Minnesota, northern Michigan, southern Michigan, and Nebraska are 1½ to 2 times as tall as neighboring pines and spruces planted at the same time. This rapid growth has made it an important timber species in New York and northern Europe.

Most of these improvements are not being put to practical use, partly due to a lack of a sustained drive on the part of researchers. The results have been publicized more in scientific journals than in newspaper releases and popularized articles that would be read by tree planters. Also, a certain amount of developmental work is necessary before some of the results can be put into practice. In this regard, I think we could borrow from the experience of the user-oriented North Carolina State-Industry program, where use of research data has received as high a priority as the scientific aspects.

Both researchers and tree planters have been loath to accept the results from 10- to 15-year-old experiments as final. We have tended to be overcautious. Undoubtedly some new varieties that show great promise at age 10 will not look so good at age 50. But this will not happen to all new varieties. In deciding to plant something that has been only partially tested, we run a certain risk. But in deciding not to plant anything new, we face the certainty of not improving our forests in the next half century.

The breeding and introduction of a new crop plant variety are only partly under the control of a plant breeder. He makes the original selections, crosses them, develops the new variety, and tests it in experimental plantings. Then he releases it to the public for commercial use, and that is when the real testing starts. Many such new varieties fall by the wayside over the years but a few succeed and raise the general level of agricultural productivity. I think we should follow this agricultural practice and make sure that our new tree varieties receive extensive testing under actual field conditions.

One way to accomplish this with minimum risk is to plant each new variety in gradually increasing amounts in small plantations or even in mixed plantations. One scheme suggested for eastern white pine in southern Michigan is to raise 100,000 Tennessee white pines, give them to nurseries, and ask the nurseries to provide each white pine buyer with 25 percent Tennessee stock and 75 percent Michigan stock. A one-row to three-row mixture would permit testing of the Tennessee trees on a broad scale with little risk.

There has been an unfortunate tendency to consider genetic tree improvement as an alternative to silvicultural management. Instead, we should consider genetic improvement and silvicultural management as complementary procedures. The new varieties will give the greatest amount of improvement if planted on good sites, given good weed control, and given proper management.

IMPROVED TIMBER VARIETIES OF THE YEAR 2,000

I have dwelled on the problem of putting research results to use because we will not have continued support for tree breeding research unless there is evidence that the results have been useful. Also, the tree planting public must become accustomed to the use of new varieties.

The past 30 years saw a tremendous amount of forest planting in the Lake States. Most of the public lands badly in need of cover are now forested. These plantations are providing a source of raw material for industry. Public response to this policy of maximum wood production from every acre has been varied and as of 1971 the wisdom of continued large-scale planting is being questioned from many sides. The wisdom of planting only for timber production is also being questioned. Thus there is no clear mandate for a tree breeder to concentrate on a single species such as white spruce or red pine that would be excellent for industrial use. Nor is there a clear mandate to concentrate on volume production or any other single trait such as wood quality. The needs both as to species and uses will continue to be varied, so I see a continuation of the present practice of working on a wide variety of species and problems.

Nevertheless, increases in growth rate will continue to loom large. Growth rate is an easy thing to measure, progress in increasing growth rate has been shown, and the demonstration of rapid growth is an easy way to obtain research support. As an example of the possibilities, I will cite red pine. The Michigan red pine progeny test-seed orchard program was started in 1961 and by 1975 should yield improved seed. There is promise of a 2 to 3 percent gain in rate of height growth. Plans are already made to start a second-generation progeny test-seed orchard program in 1975. This will use control-pollinated seed and should produce about twice as much gain as the first generation. If the heritability estimates are correct, we may obtain a total gain of 10 to 15 percent in rate of height growth by the third generation, about the year 2005.

Similar projects are planned or underway for other important species — white spruce, white pine, jack pine, and Scotch pine. Such projects are relatively inexpensive, requiring strong effort at intervals of 10 to 15 years and little effort between times. Present data indicate that the gains would not be changed very much by intensifying the effort and concentrating on a single species.

Increased disease resistance is needed in several species. Preliminary results are promising but indicate that we may have to wait some time for truly adequate varieties. I will cite an example from Scotch pine. The Belgian variety is the fastest growing and among the most susceptible to the European pine sawfly and the pine root-collar weevil. The Ural Mountain variety is resistant to the sawfly but not to the root-collar weevil and grows 25 percent slower than the Belgian variety. The Yugoslavian variety is resistant to the root-collar weevil but not to the sawfly and grows 15 percent slower than Belgian trees. It seems likely that we can obtain a good timber variety combining rapid growth, sawfly resistance, and resistance to the root-collar weevil by crossing the three varieties and selecting among the offspring for about five generations.

White-pine weevil is another important insect. Preliminary results from two different types of experiments indicate that there is little hope of obtaining a resistant variety by selection and crossing of eastern white pines in less than 20 or 30 generations. But, western white pine carries a satisfactory amount of resistance and can be crossed easily with eastern white pine. A three- or four-generation hybridization project could give us a resistant variety well adapted to the Lake States.

To tackle the production of these two resistant varieties of trees would be a new undertaking in tree breeding. It would require the preparation of 50-year work plans calling for a series of crosses to be made and test plantations to be established at intervals of 10 to 15 years, faith that the end products would justify the effort, and a single-minded concentration on getting the work done.

Becoming sidetracked is one of the greatest dangers in a long-term project such as I've outlined for Scotch pine and white pine. The approach is old-fashioned, similar to that followed by crop plant breeders for the last 50 years. There are possibilities of shortcuts — of finding a method of rooting unlimited numbers of cuttings of one good early-generation hybrid, of finding the internal cause of resistance, or of hastening flowering so that generation length can be reduced to 50 years.